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FOOD OF THE ATLANTIC CROAKER, *MICROPOGONIAS UNDULATUS*, FROM MISSISSIPPI SOUND AND THE GULF OF MEXICO[1]

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ABSTRACT The diet of the Atlantic croaker from Mississippi Sound has been examined for the first time. Over 83 taxa were encountered, or more than were reported from croaker in any other region. We also found 60 taxa, 36 of which overlapped with the above, in croaker from various offshore stations in the Gulf of Mexico. In Mississippi Sound the frequency of occurrence of items revealed primarily crustaceans followed by polychaetes, molluscs, fishes, and less common items, and, in the open Gulf, molluscs appeared slightly more often than in inshore croaker and than polychaetes in offshore fish. The diets were assessed according to length of fish, season, depth of water, and locality.

INTRODUCTION

In this study we examined the stomach and intestinal contents of many variously collected specimens of the Atlantic croaker, *Micropogonias undulatus*, a sciaenid, from Mississippi Sound and from adjacent water of the Gulf of Mexico. It presents specific identifications for numerous items and compares them, usually by taxonomic groupings, according to length of fish, season, depth of water, and geographic location.

The Atlantic croaker has an inferior mouth, sensory barbels, and coarse-straining gill rakers, all adaptations useful for feeding in and on the substratum. Chao and Musick (1977) have compared some of these features in several sciaenids and related them to feeding. The croaker usually comprises the most prevalent component of the industrial groundfish fishery in the Gulf of Mexico (Gutherz 1977) and is becoming increasingly important as a commercial foodfish (Gutherz et al. 1975). Moreover, it has always been an important component of the catch of sports fishermen in Mississippi who fish from banks and bridges and has long been recognized as a very abundant fish in the northern Gulf (e.g., Gunter 1938).

Mississippi Sound acts as a rich nursery region for juvenile croaker. Its salinities fluctuate from 0 to 37 parts per thousand (ppt), usually between 6 and 15 ppt (Christmas and Eleuterius 1973), and food for croaker and other inhabitants is typically plentiful. Soon after adult croaker spawn offshore, young fish up to 2 cm standard length (SL) begin occupying estuarine regions nearshore. This period extends from about October to February. About May, June, or July, a large proportion of that stock, then up to about 9 or 10 cm long, leaves for offshore Gulf water. Nevertheless, enough 2- and 3-year-old croaker remain in the Sound to support a sports fishery.

MATERIALS AND METHODS

Croaker were collected by a variety of means for different purposes. From Mississippi Sound, a total of 221 commercial-size fish between June 1976 and October 1977 were seasonally trawled, gill-netted, or hooked and immediately placed on ice for the primary purpose of removing and assessing the food contents. We trawled many other croaker from Mississippi Sound during 1970–1972 and 1975–1977 and maintained them alive for up to 2 days so that they could be critically examined for parasites. As for food contents, however, only the first few fish from each collection had nondigested items. Still, that material provided most of the data on croaker less than 7 cm SL (all measurements in this paper are standard lengths) plus a few from larger fish. Fishes from the Gulf of Mexico were collected from the R/V OREGON II and GEORGE M. BOWERS by members of the National Marine Fisheries Service (NMFS) between June 1974 and October 1977. Over 1,000 offshore fish came from many stations ranging from off Mobile Bay, Alabama, to off Galveston, Texas, from near shore in 11 meters depth to farther offshore at 90 meters. These fish were immediately frozen upon capture so that food contents and specific parasites could be preserved. Most had no food items when examined. Possibly as many as a half had their stomachs partially or entirely protruded by the rapid pressure difference when raised from relatively deep to surface water; consequently, they regurgitated their food.

Once removed from the measured fish, food contents were placed in 10% formalin for later identification. Because the nature of the study was not to deal with energy conversion and because the different fish had all possessed their food for different periods of time, no attempt was made to assess the volume or weight of food material.

RESULTS

Prevalence of recently fed Atlantic croaker with various dietary items appears as general, moderately general, and specific categories (Tables 1, 2, and 3). A large percentage (44%) of sampled croaker from Mississippi Sound had

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TABLE 1.

Percentage of Atlantic croaker of moderate and large sizes from inshore (I) and offshore (O) habitats containing various food items according to general category.

Fish Length in mm SL	95–198	76–195	200–350	200–351	Total	
	I	O	I	O	I	O
No. Exam.	131	1169	119	137	250	1306
No. w/Food	117	144	108	42	225	186
Food Item	Occurrence (%)					
Annelida	44.4	38.2	43.5	11.9	44.0	32.3
Mollusca	22.2	33.3	44.4	52.4	32.9	37.6
Crustacea	82.9	48.6	68.5	71.4	76.0	53.8
Fishes	17.9	0.7	28.7	14.3	23.1	3.8
Other animals	4.3	1.4	13.9	7.1	8.9	2.7
Plants	15.4		6.5	7.1	11.1	1.6
Detritus	22.2	1.4	15.7	9.5	19.1	3.2

TABLE 2.

Prevalence of feeding Atlantic croaker from Mississippi Sound with various stomach contents in relationship to season according to moderately general category.

Season	Spring	Summer	Fall	Winter	Total
No. Examined	62	100	56	32	250
No. with Food	52	87	54	32	225
Food Item	Occurrence (%)				
Hydrozoa		1.1			0.4
Annelida	48.1	50.6	37.0	31.3	44.0
Gastropoda	7.7			9.4	3.1
Scaphopoda			1.9		0.4
Pelecypoda	28.9	31.0	20.4	56.3	31.5
Cephalopoda			1.9		0.4
Ectoprocta		2.3			0.9
Echinoderma	3.9			3.1	1.3
Ostracoda	1.9	4.6			2.2
Cirripeda	1.9				0.4
Copepoda	3.9			12.5	2.7
Stomatopoda	15.4		3.7	3.1	4.9
Mysidacea	9.6	20.7	5.6	12.5	13.3
Amphipoda	28.9	50.6	9.3	3.1	28.9
Isopoda	3.9	11.5			5.3
Penaeidae	21.2	41.4	16.7	40.6	20.7
Palaemonidae	1.9	9.2			4.0
Callinectes	7.7	14.9	3.7	3.1	8.9
Other Decapoda	51.9	28.7		8.8	25.8
Other Crustacea	13.5		3.7	31.3	8.4
Insecta	3.9	9.2	1.9		4.9
Other Invertebrata	3.9	1.1		6.3	2.2
Osteichthyes	26.9	16.1	29.6	25.0	23.1
Algae	15.4	14.9	1.9		9.8
Vascular plants				3.1	0.4
Detritus	11.5	28.7	22.2	6.3	20.0

recently eaten annelids (Table 1). Of these, 79% shorter than 200 mm ate *Nereis succinea;* fewer large ones did (13%). Considering all the annelids together, possibly all polychaetes, little difference occurred between the percentage of relatively large and small fish feeding on them. Other primary dietary items consisted of pelecypods, amphipods, fishes, and penaeid shrimps (Table 2). *Mulinia lateralis* was the most prevalent pelecypod (in 28% of the 32% of croaker with bivalves), and both *Corophium louisianum* and *Ampelisca abdita* were commonly encountered amphipods (45 and 29% of the 29% of croaker with amphipods, respectively). Actually, the broad crustacean assemblage constituted the primary dietary group, being in 76% of the fed croaker. Mysids and blue crabs were common, in 13 and 9% of the fish, but less so than amphipods and shrimps. Most fish in the croaker stomachs had been digested beyond a stage necessary for identification.

Croaker-length, as already indicated, had some bearing on items consumed. Small croaker (95 to 198 mm) had more crustaceans than larger ones (83 versus 69%, respectively); whereas, an opposing relationship between item and croaker-length for both molluscs and fishes occurred: in 22 opposed to 44% and in 18 opposed to 29% of the croaker, respectively. When considering the crustaceans, we note the difference in abundance appears to reflect mostly amphipods and mysids which were found in 44 and 12% and in 19 and 7% of the large and small fish, respectively; the amphipod *Corophium louisianum* occurred in 21 and 4%, involving a total of 45% of the croaker with amphipods, and the mysid *Mysidopsis almyra* was in 16 and 4% of large and small fish, involving 77% of those fish with mysids.

Seasonality has an obvious influence on diet. Table 2 shows that the presence of amphipods, algae, portunid crabs, isopods, and miscellaneous crustaceans are most prominent during spring and summer and much less conspicuous during fall and winter. For example, amphipods occurred in 29 and 51% of the croaker in spring and summer, respectively, opposed to 9 and 3% in fall and winter. Other food items occurred more frequently during other seasons, such as penaeid shrimps in summer and winter.

Separate collections of smaller fish from the same locality provided comparative data on fish less than 70 mm long. Fish less than 25 mm fed on amphipods, ostracods, and copepods including unidentified harpacticoids, *Acartia tonsa, Pseudodiaptomus coronatus, Temora turbinata,* and others. Of 36 recently fed croaker 25 to 74 mm long, 25 contained copepods exclusively. Others contained *Palaemonetes pugio,* mysids, other shrimps, amphipods, fish remains, the spionid polychaete *Paraprionospio pinnata,* or a combination of items usually including copepods.

Atlantic croaker caught offshore demonstrated a different diet in many respects than croaker from Mississippi Sound. In two cases these results are listed in the same tables as data for inshore samples (Tables 1 and 3). The

TABLE 3.

Prevalence of feeding Atlantic croaker from Mississippi Sound and from combined offshore Gulf of Mexico stations containing various food items.

	Mississippi Sound (Fish Length in mm SL)			Gulf of Mexico (Depth in Meters)		
	95–198	200–350	Total	<30	≥30	Total
Number Fish Examined	131	119	250	77	111	188
Number Fish with Food	117	108	225	77	109	186
Food Item			Occurrence (%)			
Hydrozoan	0.9		0.4	1.3		0.5
Platyhelminth						
Stylocus ellipticus	0.9		0.4			
Nemertean		1.9	0.9			
Polychaetes						
Capitallid or oligochaete	2.6		1.3			
Diopatra cuprea	0.9	1.9	1.3	2.6		1.1
Drilonereis sp.				1.3		0.5
Glycera americana	0.9	4.6	2.7			
Glycinde sp.	4.3		2.2	1.3		0.5
Goniada sp.		0.9	0.4			
Hypaniola florida	1.7	0.9	1.3			
Nereis sp.		1.9	0.9	2.6		1.1
Nereis succinea	35.0	5.6	20.9			
Paraprionspio pinnata	0.9		0.4			
Pectinaria gouldii	0.9		0.4			
Unidentified polychaetes	7.7	33.3	20.4	49.4	18.3	31.2
Unidentified terebellid				2.6		1.1
Gastropods						
Acteocina canaliculata		0.9	0.4			
Anachis sp.		0.9	0.4	2.6		1.1
Nassarius acutus					0.9	0.5
Natica canrena					1.8	1.1
Neritina reclivata					0.9	0.5
Retusa sp.		0.9	0.4			
Sinum perspectivum				2.6		1.1
Unidentified gastropod		4.6	2.2	2.6		1.1
Scaphopod						
Dentalium sp.					3.7	2.2
Pelecypods						
Amygdalum papyrium	7.7		4.0			
Anadara transversa				1.3		0.5
Corbiculid remains				1.3		0.5
Corbula sp.		0.9	0.4		0.9	0.5
Ensis minor	0.9	0.9	0.9			
Ischadium recurvum	4.3		2.2			
Macoma mitchelli	0.9	0.9	0.9			
Mulinia lateralis	9.4	8.3	8.9	12.9		5.4
Mytilopsis leucophaeata	0.9		0.4			
Nuculana concentrica	0.9	20.3	10.2	10.4	22.9	17.8
Tagelus plebeius	1.9	0.9	1.3			
Tellina sp.	1.7	1.9	1.8			
Varicorbula operculata					0.9	0.5
Unidentified bivalve remains	0.9	10.2	5.3	1.3	1.8	1.6
Cephalopod						
Octopus sp.		0.9	0.4			
Ostracod	0.9		0.4		1.8	1.1
Cirripeds						
Balanus improvisus	3.4		1.8			
Unidentified barnacle	0.9		0.4			

TABLE 3 (Continued).

Prevalence of feeding Atlantic croaker from Mississippi Sound and from combined offshore Gulf of Mexico stations containing various food items.

	Mississippi Sound (Fish Length in mm SL)			Gulf of Mexico (Depth in Meters)		
	95–198	200–350	Total	<30	≥30	Total
Number Fish Examined	131	119	250	77	111	188
Number Fish with Food	117	108	225	77	109	186
Food Item	Occurrence (%)					
Copepods						
Calanoid	0.9	3.7	2.2			
Unidentified copepod	0.9		0.4		1.8	1.1
Stomatopods						
Squilla dicepirix					1.3	0.5
Squilla edentata		0.9	0.4			
Squilla empusa	0.9	3.7	2.2	5.2		2.2
Squilla remains	0.9	4.6	2.7	1.3	11.9	7.5
Mysid						
Mysidopsis almyra	20.5	6.5	13.8			
Cumacean		6.5	3.1		0.9	0.5
Amphipods						
Ampelisca abdita	14.5	1.9	8.4			
Ampelisca sp.	3.4	3.7	3.6		0.9	0.5
Cerapus sp.	11.9	4.6	8.4			
Corophium louisianum	21.4	3.7	12.8			
Gammarus mucronatus	5.1		2.7			
Gammarus tigrinus	1.7		0.9			
Haustorid		0.9	0.4			
Melita nitida	2.6		1.3			
Unidentified amphipod	0.9	2.8	1.8			
Tanaidacean						
Leptochela sp.		9.3	4.4		0.9	0.5
Isopods						
Cassidinidea lunifrons	0.9		0.4			
Cyathura polita	2.6	5.6	4.0			
Edotea montosa	0.9		0.4			
Isopod remains	0.9		0.4			
Penaeids						
Parapenaeus longirostris		0.9	0.4		1.8	1.1
Penaeus aztecus	3.4	5.6	4.4			
Penaeus remains	30.8	21.3	26.2	3.9	8.3	6.5
Penaeus setiferus	1.7	0.9	1.3			
Sicyonia dorsalis					1.8	1.1
Trachypenaeus sp.				1.3		0.5
Sergestid						
Acetes americanus				2.6	4.6	3.8
Carideans						
Alpheus floridanus		9.3	4.4		8.3	4.8
Alpheus sp.				1.3	0.9	1.1
Ogyrides limicola	1.7		0.9	1.3	0.9	1.1
Palaemonetes pugio	5.9	1.9	4.0			
Synalpheus townsendi		0.9	0.4	1.3		0.5
Unidentified caridean		2.8	1.3	1.3	3.7	2.7
Anomurans						
Albunea gibbesi		0.9	0.4	3.9	0.9	2.2
Callianassa jamaceae	1.7	2.8	2.2			
Callianassa remains		0.9	0.4		0.9	1.1
Pagurus spp.	0.9		0.4	2.6	21.1	13.4

TABLE 3 (Continued).

Prevalence of feeding Atlantic croaker from Mississippi Sound and from combined offshore Gulf of Mexico stations containing various food items.

	Mississippi Sound (Fish Length in mm SL)			Gulf of Mexico (Depth in Meters)		
	95–198	200–350	Total	<30	≥30	Total
Number Fish Examined	131	119	250	77	111	188
Number Fish with Food	117	108	225	77	109	186
Food Item	Occurrence (%)					
Brachyurans						
Calappa sp.					0.9	0.5
Callinectes remains		2.8	1.3			
Callinectes sapidus	11.1	4.6	8.0	2.6		1.1
Callinectes similis		1.9	0.9			
Chasmocarcinus mississippiensis					0.9	0.5
Eurypanopeus depressus	1.7		0.9			
Euryplax nitida		6.5	3.2			
Hepatus epheliticus				1.3		0.5
Hexapanopeus angustifrons		0.9	0.4		0.9	0.5
Leiolambrus nitidus		1.9	0.9	1.3	0.9	1.1
Pinnixa sp.					0.9	0.5
Portunus gibbesi				1.3		0.5
Portunus spp.		3.7	1.8		4.6	2.7
Raninoides louisianensis					2.8	1.6
Rhithropanopeus harrisi	17.1	2.8	10.2			
Solenolambrus sp.					0.9	0.5
Unidentified branchyuran larva		0.9	0.4			
Unidentified goneplacids		0.9	0.4	6.5	13.8	10.7
Unidentified xanthid	5.1	4.6	4.9	1.3		0.5
Unidentifiable decapod remains		2.8	1.3			
Insect						
Chironomid midge larva	6.8	2.8	4.9			
Ectoprocts						
Bowerbankia gracilis	0.9		0.4			
Membranipora arborescens	0.9	0.9	0.9			
Chaetognath				1.3		0.5
Echinoderms						
Echinoid remains		2.8	1.3		0.9	0.5
Hemipholis elongata				3.9	0.9	2.2
Fishes						
Anchoa hepsetus		0.9	0.4			
Anchoa mitchilli	1.7	5.6	3.6	2.6		1.1
Anguilliform remains	0.9		0.4			
Gobiosoma bosci	2.6	0.9	1.8			
Microdesmus longipinnis		0.9	0.4			
Symphurus plagiusa		0.9	0.4			
Unidentifiable fish parts	11.1	24.0	17.3	7.8	1.8	4.3
Unidentifiable goby	0.9	0.9	0.9			
Plants						
Algae and unidentified plant matter	18.8	1.9	10.7	1.3		0.5
Sea grass		0.9	0.4			
Detritus and other organic matter	23.1	17.6	20.4	7.8		3.2

offshore croaker feed most commonly on crustaceans (54% of the fish with food), but also on molluscans and annelids (38 and 32%, respectively). Crustaceans occurred most frequently in samples from water deeper than 30 meters (69 versus 33% in water less than 30 m) and from larger fish (71 versus 49% in relatively short fish). Actually, crustaceans, the general food most frequently observed to be consumed from both inshore and offshore habitats, had a higher prevalence in inshore croaker. In fact, of the major general categories, only molluscs occurred in more offshore croaker,

and then not substantially (Table 1). Offshore molluscs, primarily bivalves, show similar relationships as the offshore crustaceans with water-depth and with fish-length. On the other hand, offshore annelids, primarily polychaetes, occurred most commonly in the shallower samples (in 52 versus 18% of the fish) and in smaller fish (38 versus 12%). Other less common items such as fishes, plants, and detritus all occurred slightly more frequently in the large croaker from shallower offshore water.

Specific animals, as expected, typically occurred most frequently in specific regions. For examples, the bivalve *Nuculana concentrica* occurred most frequently in deeper water as did the hermit crabs, *Pagurus* spp. We also point out that more smaller fish had hermit crabs than those fish longer than 20 cm. On the other hand, the stomatopod *Squilla empusa* occurred in fish only from the shallower localities.

DISCUSSION

The long list of different food items in the Atlantic croaker constitutes the most important aspect of this study. Differences in dietary organisms taken from inshore and offshore samples reflect a difference in components of the communities from the two general regions. A more complete delineation of the localities would have emphasized the differences in communities even more.

Stomach contents of croaker had not been previously reported from Mississippi waters. Our data reveal some differences among samples according to depth, length of fish, and season, as well as to locality. In addition to mere examination of tables listing and comparing the percentage/frequency of occurrence for different items, we compared some of the values statistically. For example, using Wilcoxon's signed rank test (Steel and Torrie 1960:402) we accept the hypothesis that the frequencies of the various food items differ between fish less and greater than 200 mm in both Mississippi Sound (T_{lesser} = 147.5 and 147.5 > $61_{\alpha=.01}$, n=24) and the Gulf of Mexico (T_{lesser} = 33 and 33 > $23_{\alpha=.01}$, n=17); however, the ranks of the frequencies of those items do not significantly differ between inshore and offshore stocks (T_{lesser} = 61.5 and 61.5 < $68_{\alpha=.01}$, n=25). Still a Spearman's rank test (Fritz 1974) suggests that compared ranks in all three comparisons are correlated: r_s = 0.582, 0.627, and 0.521 with "t" = 3.360 > $2.819_{\alpha=.01}$, 22df, 3.116 > $2.947_{\alpha=.01}$, 15dt, and 2.924 > $2.807_{\alpha=.01}$, 23df, respectively. A Friedman test (Conover 1971) was used to compare the generalized items by season. In this case, T = 5.06, and 5.06 < $11.34_{\alpha=.01,3df}$, allowing us to accept the null hypothesis that no difference exists for the croaker's diet among any of the seaons. This result, however, might be misleading because of the high prevalence of fish in the croaker stomachs during the fall and the low prevalence during the summer. Inspection of the less generalized items in Table 2 shows a lower prevalence in fall than in other seasons for crustaceans, as well as other variations.

Parker (1971) used the Spearman's rank test to compare differences in ranked frequencies between food items from Texas and Louisiana in different croaker-length groups. In order to compare our findings for large fish with his, we joined some less common groups together, deleted the group for mud and sand since we did not always document that category in our material, ranked the values, and compared them with the corresponding ones for croaker from Louisiana and Texas. The results of the tests do not indicate that a correlation exists between the paired groups (r_s = 0.467 and 0.155 when compared with values from Louisiana and Texas, respectively; "t" = 2.243 and 0.667 with those values less than $t_{\alpha=.01,\ 18df}$ = 2.878). When ranking the least frequent item as 1 (as suggested by Fritz [1974]) rather than the most frequent one, we obtained r_s = 0.465 and 0.138 with "t" = 2.231 and 0.589, indicating the same conclusions. Additionally we used Wilcoxon's test and accept the alternative hypothesis that the croaker's diet in Mississippi Sound differs from that encountered in both Louisiana (T_{lesser} = 45.5, 45.5 > $38_{\alpha=.01}$, n=20) and Texas (T_{lesser} = 56, 56 > 38).

Several analyses of the croaker's food contents have been conducted. Of these, no reason exists not to believe that the croaker acts opportunistically, feeding on any easily available prey. Some learning behavior may occur because specific individuals from a collection of confined fish occasionally had exclusively fed on specific food items different from those found in their counterparts. This observation was especially conspicuous for small croaker heavily packed with *Pseudodiaptomus coronatus, Corophium louisianum,* or other small crustaceans, but it also occurred for larger croaker feeding on large prey. Darnell (1958) noted the same tendency for a few young croaker to specialize on chironomids, mysids, or amphipods. We found that most individuals fed on a variety of items.

A large number of authors have reported mostly unidentified food items from croaker. One paper by Stickney et al. (1975), however, presented an extensive list with 58 different taxa in croaker from Georgia. We found over 83 taxa in Mississippi Sound and 60 in the Gulf including 36 that overlapped between the two regions. Chao and Musick (1977) referenced most of the studies from the Atlantic coast. Those studies from the Gulf of Mexico are by Gunter (1945), Reid (1955), Reid et al. (1956), Darnell (1958), Inglis (1959), Avault et al. (1969), Hanson (1969), Fontenot and Rogillio (1970), Parker (1971), Day et al. (1973), Diener et al. (1974), Weaver and Holloway (1974), Roussel and Kilgen (1975), and Chen (1976).

Croaker from different localities feed on the same general items, but often in different proportions and on different specific components. In general, croaker feed on crustaceans, polychaetes, pelecypods, fishes, detritus, and miscellaneous invertebrates and plants. Several factors obviously dictate the proportions and compositions of these food items, but

these factors have been inadequately studied. Reid (1955) found 45% of a sample from East Bay, Texas, fed on molluscs and 13% on shrimp. After construction of Rollover Pass, an entrance allowing introduction of water from the Gulf into the Bay, Reid et al. (1956) found a decreased frequency of croaker, and of the sample, 98% fed on molluscs, but still 13% on shrimp. Data from our tables reveal some differences according to length of fish, season, locality, and depth of water. Other papers also revealed differences related to various variables. As an example, Farrell (1970) showed a seasonal variation in amphipod consumption with most amphipods eaten in spring and early summer in Mississippi Sound, but differing somewhat by exact locality. Species of *Corophium* predominated.

Commercial shrimps and blue crabs constituted a sizeable portion of the diet in croaker from Mississippi and a few, but not all, other Gulf locations. In spite of the high prevalence of penaeids in localities inhabited by the croaker in Georgia and North Carolina, few individual croaker ate these shrimp; rather, they utilized *Neomysis americana* (Stickney et al. 1975).

Stickney and coworkers pointed out that few taxa occurred in large numbers of croaker, citing *N. americana* in 17% of the croaker as the most frequent item the authors encountered. We observed several food items that occurred more often. In croaker from Mississippi Sound, *Penaeus* spp. (in most cases, the remains of *Penaeus aztecus* were not differentiated from those of *P. setiferus*) occurred in 30% of the fish and the polychaete *Nereis succinea* in 21%. Members of neither taxon was common offshore (5% of offshore croaker did contain *Penaeus* spp.), but hermit crabs in the genus *Pagurus* occurred in 13% of the offshore fish, 21% of those fish from deeper than 30 m, and rarely in croaker from the Sound. The bivalve *Nuculana concentrica* was found in 18% of the offshore croaker and 10% of the inshore ones.

Primary species comprising each general group differ from habitat to habitat. As an example, we consider clams. Whereas the razor clam constitutes the most common bivalve food item for the croaker along many Atlantic coast localities, its role is substituted elsewhere. *Rangia cuneata* fills this role in Lake Pontchartrain, *Mulinia lateralis* and *Nuculana concentrica* in Mississippi Sound, and *Macoma mitchelli* in East Bay, Texas. In regions where more diversified bivalve populations occur such as in the Gulf of Mexico, dominant forms may be less conspicuous. *Nuculana concentrica* occurred in many of the croaker we examined, but large samples from other sites would probably yield other common species.

Our offshore samples do not represent a single locality. In fact, fish with food came from 32 different stations over a 3-year period. As indicated earlier, most individuals did not have food present and obtaining food data was a secondary mission. Nevertheless, our data reveal some valuable generalizations about the food of the offshore Gulf croaker.

Food contents of croaker also collected by the NMFS during a portion of the same period, but with only two overlapping stations, were analyzed by Chen (1976). She grouped data from different stations and found contents in 300 croaker 26 to 339 mm SL to have a frequency of occurrence greatest for polychaetes (53%), followed by natantian decapods (47%), mysidaceans (20%), amphipods (12%), brachyurans (11%), brittle stars (11%), and other less common items. Ninety percent of the croaker had organic or inorganic matter, presumably most of which were partially digested items.

The primary differences between our findings and those of Chen are that in our samples molluscs occurred more frequently and the diet was much more diversified. We did not encounter as many polychaetes and found no mysids or ophiuroids. According to Chen's graphs separating diet by size of fish, the fish in three unspecified size-groups generally appeared to have similar diets.

Comparison of Chen's and our data, just like comparison of most data from the same or from different areas, shows that portions of croaker diet may vary significantly among compared samples. The difference probably primarily reflects the availability of the specific items at a specific collecting site.

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REFERENCES CITED

Avault, J. W., Jr., C. L. Birdsong & W. G. Perry, Jr. 1969. Growth, survival, food habits and sexual development of croaker, *Micropogon undulatus*, in brackish water ponds. *Proc. Southeast. Game Fish Comm.* 23:251.

Chao, L. N. & J. A. Musick. 1977. Life history, feeding habits, and functional morphology of juvenile sciaenid fishes in the York River estuary, Virginia. *Fish. Bull., U.S.* 75(4):657–702.

Chen, L.-S. 1976. Food habits of the Atlantic croaker, *Micropogon undulatus* (Linnaeus), and the spot, *Leiostomus xanthurus* Lacépède in the northcentral Gulf of Mexico. Master's thesis, Univ. Southern Mississippi, Hattiesburg. 61 pp.

Christmas, J. Y. & C. K. Eleuterius. 1973. Phase II: Hydrology. Pp. 73–121 in *Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi.* Gulf Coast Research Laboratory, Ocean Springs, Mississippi.

Conover, W. J. 1971. *Practical Nonparametric Statistics.* John Wiley & Sons, Inc., New York. 462 pp.

Darnell, R. M. 1958. Food habits of fishes and larger invertebrates

of Lake Pontchartrain, Louisiana, an estuarine community. *Publ. Inst. Mar. Sci., Univ. Tex.* 5:353–416.

Day, J. W., Jr., W. G. Smith, P. R. Wagner & W. C. Stowe. 1973. *Community Structure and Carbon Budget of a Salt Marsh and Shallow Bay Estuarine System in Louisiana.* Publication No. LSU-SG-72-04, Center for Wetland Resources, Louisiana State University, Baton Rouge. 80 pp.

Diener, R. A., A. Inglis & G. B. Adams. 1974. Stomach contents of fishes from Clear Lake and tributary waters, a Texas estuarine area. *Publ. Inst. Mar. Sci., Univ. Tex.* 18:7–17.

Farrell, D. H. 1970. Ecology and seasonal abundance of littoral amphipods from Mississippi. Master's thesis, Mississippi State Univ., Starkville. 62 pp.

Fontenot, B. J., Jr. & H. E. Rogillio. 1970. A study of estuarine sport-fishes in the Biloxi marsh complex, Louisiana. Dingell-Johnson Project F–8 Completion Report for Louisiana Wildlife and Fisheries Commission. 172 pp.

Fritz, E. S. 1974. Total diet comparison in fishes by Spearman rank correlation coefficients. *Copeia* 1974(1):210–214.

Gunter, G. 1938. The relative numbers of species of marine fish on the Louisiana coast. *Am. Nat.* 72:77–83.

_____. 1945. Studies on marine fishes of Texas. *Publ. Inst. Mar. Sci., Univ. Tex.* 1(1):1–190.

Gutherz, E. J. 1977. The northern Gulf of Mexico groundfish fishery, including a brief life history of the croaker (*Micropogon undulatus*). *Gulf Caribb. Fish. Inst. Proc., 29th Ann. Sess.* 87–101.

_____, G. M. Russell, A. F. Serra & B. A. Rohr. 1975. Synopsis of the northern Gulf of Mexico industrial and foodfish industries. *U.S. Natl. Mar. Fish. Serv., Mar. Fish. Rev.* 37(7):1–11.

Hansen, D. J. 1969. Food, growth, migration, reproduction, and abundance of pinfish, *Lagodon rhomboides*, and Atlantic croaker, *Micropogon undulatus*, near Pensacola, Florida, 1963–65. *U.S. Fish. Wildl. Serv. Fish. Bull.* 68(1):135–146.

Inglis, A. 1959. Predation on shrimp. *U.S. Fish. Wildl. Serv. Circ.* 62:50–53.

Parker, J. C. 1971. *The Biology of the Spot*, Leiostomus xanthurus *Lacepède, and Atlantic Croaker*, Micropogon undulatus *(Linnaeus), in Two Gulf of Mexico Nursery Areas.* Sea Grant Publication No. TAMU–SG–71–210. Tex. A&M Univ., College Station. 182 pp.

Reid, G. K., Jr. 1955. A summer study of the biology and ecology of East Bay, Texas. Part II. The fish fauna of East Bay, the Gulf beach, and summary. *Tex. J. Sci.* 7(4):430–453.

_____, A. Inglis & H. D. Hoese. 1956. Summer foods of some fish species in East Bay, Texas. *Southwest. Nat.* 1(3):100–104.

Roussel, J. E. & R. H. Kilgen. 1975. Food habits of young Atlantic croakers (*Micropogon undulatus*) in brackish pipeline canals. *Proc. La. Acad. Sci.* 38:70–74.

Steel, R. G. D. & J. H. Torrie. 1960. *Principles and Procedures of Statistics with Special Reference to the Biological Sciences.* McGraw-Hill, New York. 481 pp.

Stickney, R. R., G. L. Taylor & D. B. White. 1975. Food habits of five species of young southeastern United States estuarine Sciaenidae. *Chesapeake Sci.* 16(2):104–114.

Weaver, J. E. & L. F. Holloway. 1974. Community structure of fishes and macrocrustaceans in ponds of a Louisiana tidal march [sic] influenced by weirs. *Contrib. Mar. Sci.* 18:57–69.